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NORWEGIAN BLUE WHITING INVESTIGATION IN MARCH/APRIL 1981

by

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ABSTRACT

Acoustic measurements on blue whiting in the area north and west of Scotland were carried out from 9 March to 4 April 1981. The survey was in partly coordination with a U.K. survey, and an intercalibration of the two vessels' acoustic instruments was worked. The Norwegian research vessel recorded blue whiting in various densities over the whole area from the western coast of Norway to the northern coast of Ireland, with highest concentrations off the slope west of the Hebrides.

The assessment of the stock within the are between latitudes $55^{o}30'$ and $65^{o}00'$ gave a total of 6.9 mill. tonnes of blue whiting. Of this, 6.0 mill. tonnes belonged to the spawning stock and 0.9 mill. tonnes were immature fish.

INTRODUCTION

In 1980 the total landings of blue whiting reached 1.1 mill tonnes, which is similar to the figure of 1979. Of this, Norway contributed with 144 000 tonnes from the directed fishery in the spawning area and another 31 000 tonnes mainly from the mixed industrial fishery in the North Sea. In 1981 the Norwegian fleet has up to end of May landed around 170 000 tonnes from the directed fishery. However, the major part of the total blue whiting landings, more than 767 000 tonnes in 1980, are taken in the Norwegian Sea, where the international fishery takes place more or less throughout the year. (Anon, 1981).

Since 1972, acoustic assessments of blue whiting has mainly been concentrated upon the spawning stock when it is congregated in the area west of the British Isles. Though the major part of the blue whiting stock in the Northeast Atlantic spawn in this area, not all of the spawners are found inside a defined area at the same time. Migration of fish to and from the spawning area goes on from early March to late May, and hence acoustic surveys in the area only covers part of the total spawning stock.

The estimates of blue whiting therefore have some variation from year to year due to the actual area covered and time period for the surveys (Monstad 1979).

In 1979 and 1980, the Norwegian acoustic estimates of blue whiting in the spawning area in April were 7.9 and 5.4 mill tonnes respectively (Monstad and Midttun 1980).

In 1981 the Norwegian blue whiting investigations to the spawning area were made with the research vessels "G.O.Sars" and "Michael Sars". While the main objective of the latter was to operate as a scouting vessel for the commercial fleet, "G.O.Sars" (9 March - 4 April), partly in coordination with the British research vessel "Scotia", measured the blue whiting abundance acoustically.

"G.O. Sars" covered the middle and northern part of the area west of the British Isles, and "Scotia" the middle and southern part. In this way as large as possible part of the potential spawning area could be covered within a reasonable time period, and an overlapping area of which the two vessels' results could be compared. In addition a "ship to ship" acoustic calibration was carried out.

The assessments of blue whiting from the two vessels' recordings were analysed and the results combined. This, together with the total figure of blue whiting observed, are discussed in the Blue Whiting Assessment Working Group report of 1981 (Anon 1981).

METHODS

The cruise track design (Fig. 1) was chosen in accordance with the running observations of blue whiting concentrations and the disposal time. Pelagic trawl hauls were made accordingly for identification of the recordings and collection of biological samples, as were CTD-sonde stations worked for hydrological observations. The courses were also set in a way that made it possible to draw isolines on a map of the recorded echo intensity with as well defined "zero-lines" as possible. The recordings, made by a 38 kHz echosounder connected to a digital echointegrator, were expressed in mm deflection per nautical mile as 40 dB-values. In general, the water column down to 500 m was sampled with 7 channels of the echo-integrator, each channel collecting from a depth interval of either 50 or 100 m. An 8th channel sampled the area from bottom to 5 m above.

The echorecording paper of every nautical mile steamed, were analysed in accordance with the results of trawlsamples representative for the location in question. The corresponding echointensity was divided, and appropriate parts of it given to various kind of fish species or plankton. The blue whiting values were mappped along the cruise tracks, and the total area

of distribution observed, divided into rectangles of 0.5^{o} latitude and 1^{o} longitude size. For each of the rectangles the horizontal size of distribution and the representative length-age and maturity composition of the blue whiting were given, together with the mean echo intensity value. For those rectangles within the area of distribution, which have not been covered by any course line, interpolated values were given.

The abundance of blue whiting biomass were then estimated for each of the rectangles, based upon the relationship between fish density and echo intensity described by FORBES and NAKKEN (1972). The fish specie and length-dependent connection factor, C-value, is the same that is established for cod, and used for the similar blue whiting surveys in 1979 and 1980 (Monstad and Midttun, 1980):

$$C = 5.25 \times 10^{6} \times l^{-2.18}$$

and expressed as nos. of fish per mm integrator deflection per square nautical mile when l is the fish length.

During two of the trawl stations on the cruise, target strength (TS) in situ-measurements were worked on blue whiting single-echoes. The echo-signals were sampled by a computer connected to the echo-sounder, and reduced after the method described by CRAIG and FORBES (1969). In total, approximately 10 000 echo signals were sampled, and the ones obtained in the acoustic axis were selected, combined and grouped. The result is shown in Fig. 2 together with the length distribution of the blue whiting sampled during the experiments.

The 50%-values of the two distribution are -39 dB for target strength and 32 cm for the fish length, which fit with the expected values in the field of fish length-target strength realtionship for cod, established by NAKKEN and OLSEN (1977). These give then the basis of using the same C-value for blue whiting as for cod.

RESULTS AND DISCUSSION

Distribution

During the first half of the cruise the area from western Norway to the Faroes-Hebrides was covered, and the results of the echo recordings are shown in Fig. 3. Between latitudes 61° and 65°, blue whiting were distributed more or less scattered from the Norwegian trench to east of Faroe Isles. Between the Faroes and the Hebrides rather good recordings of blue whiting were made also in this period. However, the weather was too rough to permit a reliable description of the distribution. This is therefore only indicated by dotted lines in the figure.

During the second half of the cruise, the area from northern coast of Ireland to Shetland, and to the Rock All Bank was surveyed. The distribution and relative densities of blue whiting recorded are shown in Fig. 4. Blue whiting was found in the usual pattern, congregating mostly near the shelf in depths from approximately 300 to 500 m.

However, the highest concentrations were located in the area off the slope west of the Hebrides during this period. Here rather large shoals were recorded in depths from 500 to 650 m. While the blue whiting recorded nearer to the coast were shoaled during day and scattered during night, the blue whiting recorded more offshore at deeper water, remained shoaled both day and night.

The surveying west to the Rock All Bank area, gave only negligible recordings of blue whiting.

As mentioned above, only part of the spawning stock was surveyed by "G.O.Sars". Besides of "Scotia" (Anon. 1981), R/V "Michael Sars" extended the survey area southward to the Porcupine Bank west of Ireland (Fig. 5) and in second half of March observed good concentrations all the way along the slope (Dahl, 1981).

The southern limit of the distribution was not defined, but highest concentrations were located at the bank, where also the commercial fleet took rather good catches during this period. In the last days of March, the fleet shifted operation area to the concentrations off the Hebrides.

Abundance

The assessment of blue whiting within the area covered by "G.O. Sars" were made for two periods of the cruise, north and south of 61°N respectively. In Fig. 6 are shown the total abundance by each statistical rectangle, given in thousands of tonnes. In the period 9-20 March in the area between the latitudes 61° and 65°, the abundance of blue whiting was assessed to 2.3 mill tonnes. Of this 0.5 mill tonnes were immatured specimens.

In the period 20 March-2 April between the latitudes 55°30' and 61°00' the assessment gave 4.6 mill tonnes of blue whiting, including 0.4 mill tonnes of immature fish. For the whole area surveyed this gives a total of 6 mill tonnes belonging to the spawning stock, and 0.9 mill tonnes of immature blue whiting.

The area north of 61°N was surveyed from north to south, and the area south of 61°N surveyed from south to north. With the southward movement of the blue whiting in north, and the time difference between the two coverages, there is a possibility of parts of the stock being measured twice, and hence the figure of 6 mill tonnes may be a slight overestimate.

Structure

Total length distribution of blue whiting from the trawlsamples is given in Table 1, and the age-composition in Table 2. The ages from 1 to 15 years with traces of slightly older fish, were represented in the stock. Three year old fish were most common, making up almost 20 percent of the samples. In 1980, the same year-class also dominated in the samples, with a total of more than 25 percent (Midttun and Monstad, 1980).

In Fig. 7 the length- and age-compositions in the samples are shown for different subareas. These are outlined in Fig. 7. The youngest and smallest fish were found in the area west of the Faroes, and here the one and the three year olds made up the majority of the recordings, and the two year olds almost lacked. The area north and west of the Hebrides, representing the biggest part of the stock observed, had fish of highest mean length and age. Though the three years old fish were most numerous with 19 percent, the age groups from five to nine years together made up more than 50 percent of the samples.

Spawning had started in small scale in mid March, and the few ripe and spent specimens were mostly found nearest to the coast within the area of distribution (Table 3). Most of the three year old specimens were sexual mature, and also some of the two year olds.

The length-weight relationships of the blue whiting from the whole area investigated, are shown in Table 4. Between the same four subareas given in Fig. 7, there were only minor differences in this relationship. Compared to the situation in the two previous years the mean weight in each length group are found to be higher than those observed in 1980, which again are higher than those of 1979 (Monstad and Midttun, 1980). Some of this difference can be explained by the sampling periods, the 1981-survey being one month earlier, and hence lesser spent fish were observed.

Intercalibration

On 27 March a "ship to ship" calibration between the acoustic instruments of "G.O. Sars" and "Scotia" was carried out. This was to check the similarity of the observations and a trial to establish a reliable conversion factor between the two vessels' echo recordings. In an area west of the Hebrides, "Scotia" steamed first with "G.O. Sars" 0.5 nautical mile behind and 0.1 n. mile to the starbord to avoid propeller noise. The water column was recorded in three intervals,

channel 1 from 100 to 250 m and channel 2 from 300 to 500 m depth and a channel that recorded from bottom to 50 m above. Recordings from the bottom channel were incorporated in channel 2. A distance of 54 nautical miles was steamed.

Owing to bad weather conditions during the experiment a lot of "noise" disturbed the recordings, and several of the miles had to be omitted from the calculations. Fig. 8 shows the two vessels recorded values per nautical mile, with the two channels treated separately. The regression line is shown in Fig. 9, with the relationship:

$$M_{G.O.Sars} = 14.1 \times B_{Scotia} + 48.1$$

$$r = 0.907$$

M is the echo intensity in mm deflection per nautical mile, B the biomass in tonnes per square km and r the correlation coefficient.

Hydrography

The horizontal temperature conditions at sea surface, 200 m and 400 m are shown in Figs. 10, 11 and 12 respectively. Salinity conditions for the same three depths are shown in Figs. 13, 14 and 15. The vertical temperature situations are shown in sections between the Faroes and Shetland and between the Faroes and the Hebrides in Figs. 16 and 17 respectively.

The temperatures were much the same as observed one year before. In the area west of Scotland there were rather homogenous conditions with temperature of 9°C and salinity of 35.3 °/oo. East of the Faroes colder water with lesser salinity penetrated southwards from the Norwegian Sea. The values decreasing gradually with the depth down to 400 m and then more sharply declined (Fig. 17).

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Table 1. Total length distribution of blue whiting in the trawl samples from the Faroes-Shetland-Scotland area in March 1981.

cm		18		20		22		24		26		28		30		32		34		36		38		40	N
%	0.2	1.5	1.7	1.6	0.9	0.9	1.3	3.6	4.1	6.1	7.0	5.1	6.5	9.9	12.8	13.8	9.8	6.5	3.1	1.8	1.0	0.5	0.1	0.2	1897

Table 2. Total age distribution of blue whiting in the trawl samples from the Faroes-Shetland-Scotland area in March 1981.

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	N
%	5.9	5.8	19.6	8.0	8.8	11.5	11.9	9.4	6.7	4.6	3.5	2.4	1.0	0.6	0.4	1897

Table 3. Maturity composition, in percentage, of blue whiting in trawl samples from the four areas outlined in Fig. 7, March 1981.

Maturity stage	Area A N and W of Hebrides	B W of Faroes	C E of Faroes	D N and NE of Shetland
immature	10.1	55.0	24.7	39.3
maturing[x)]	82.8	45.0	75.3	60.7
ripe	6.6	-	-	
spent	0.4	-	-	
N	1252	149	259	237

x) also including spent and recovering specimens.

Table 4. Mean weight (g) and numbers in length groups of blue whiting in the trawl samples from the Faroes-Shetland-Scotland area in March 1981.

cm		18		20		22		24		26		28		30		32		34		36		38		40	
$\bar{v}$	26.3	29.0	35.7	41.9	49.2	62.4	68.5	79.9	91.1	102.2	113.3	126.2	140.8	152.8	167.6	184.5	201.4	224.4	240.1	265.0	288.7	335.0	355.0	397.5
n	4	29	33	30	18	17	24	71	77	118	133	98	129	193	251	279	201	133	65	40	19	10	2	4

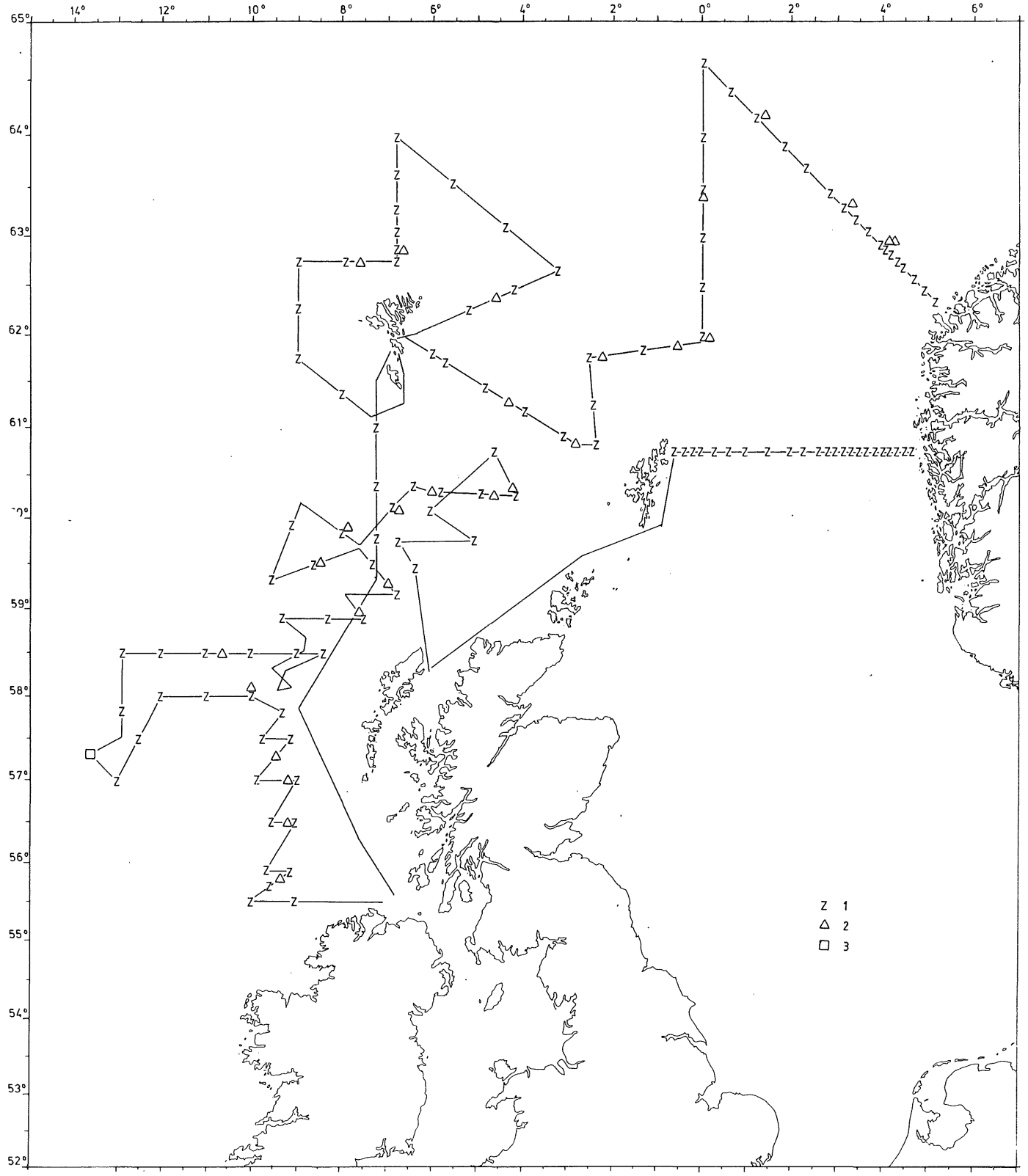

Fig. 1. Cruise track with stations of R/V "G.O. Sars", 9 March-4 April 1981. 1) CTD-sonde station, 2) Pelagic trawl station, 3) Bottom trawl station.

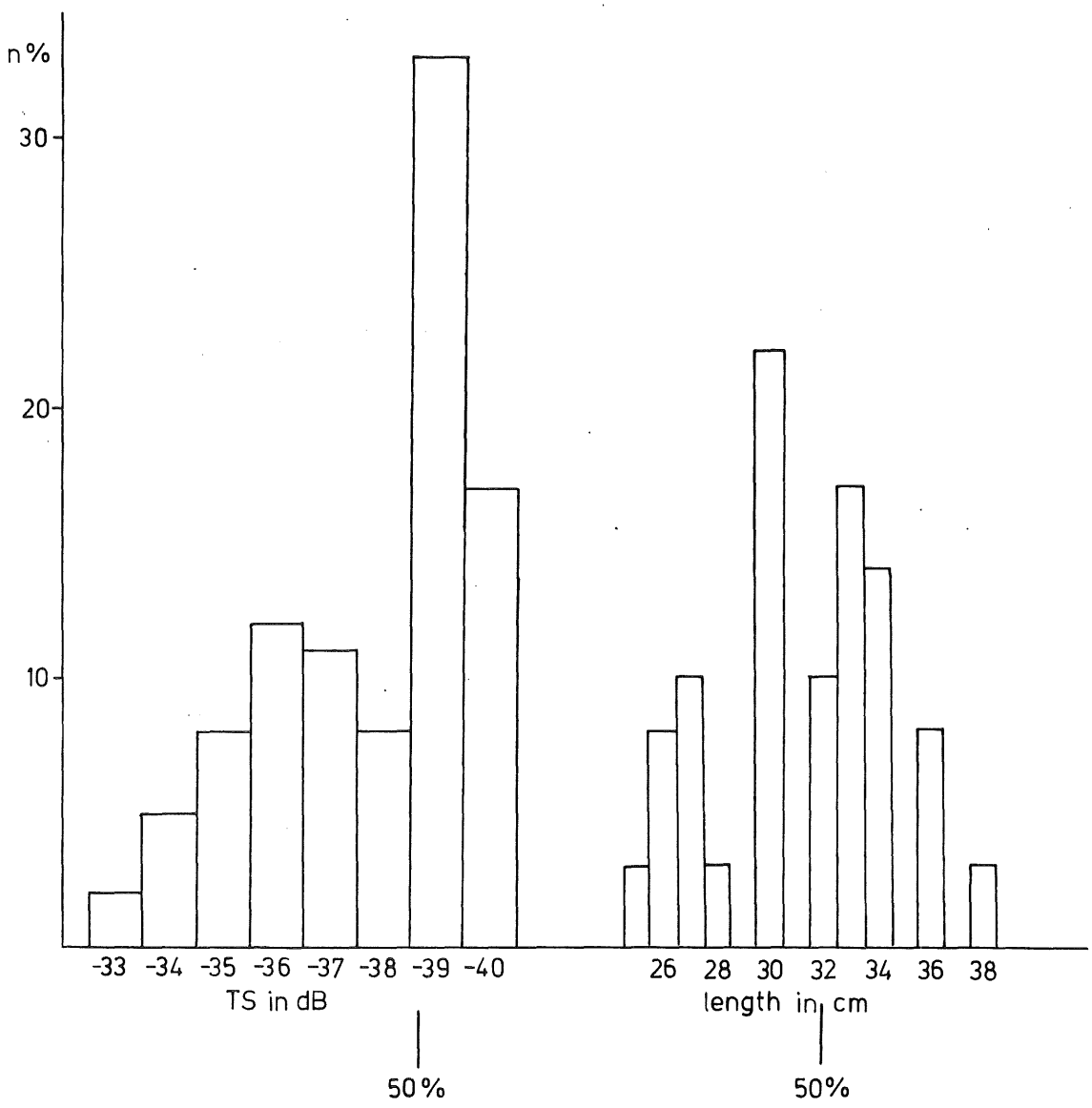

Fig. 2. Target strength (TS) distribution from "in situ"-measurements and length distribution from corresponding trawl samples of blue whiting, March 1981.

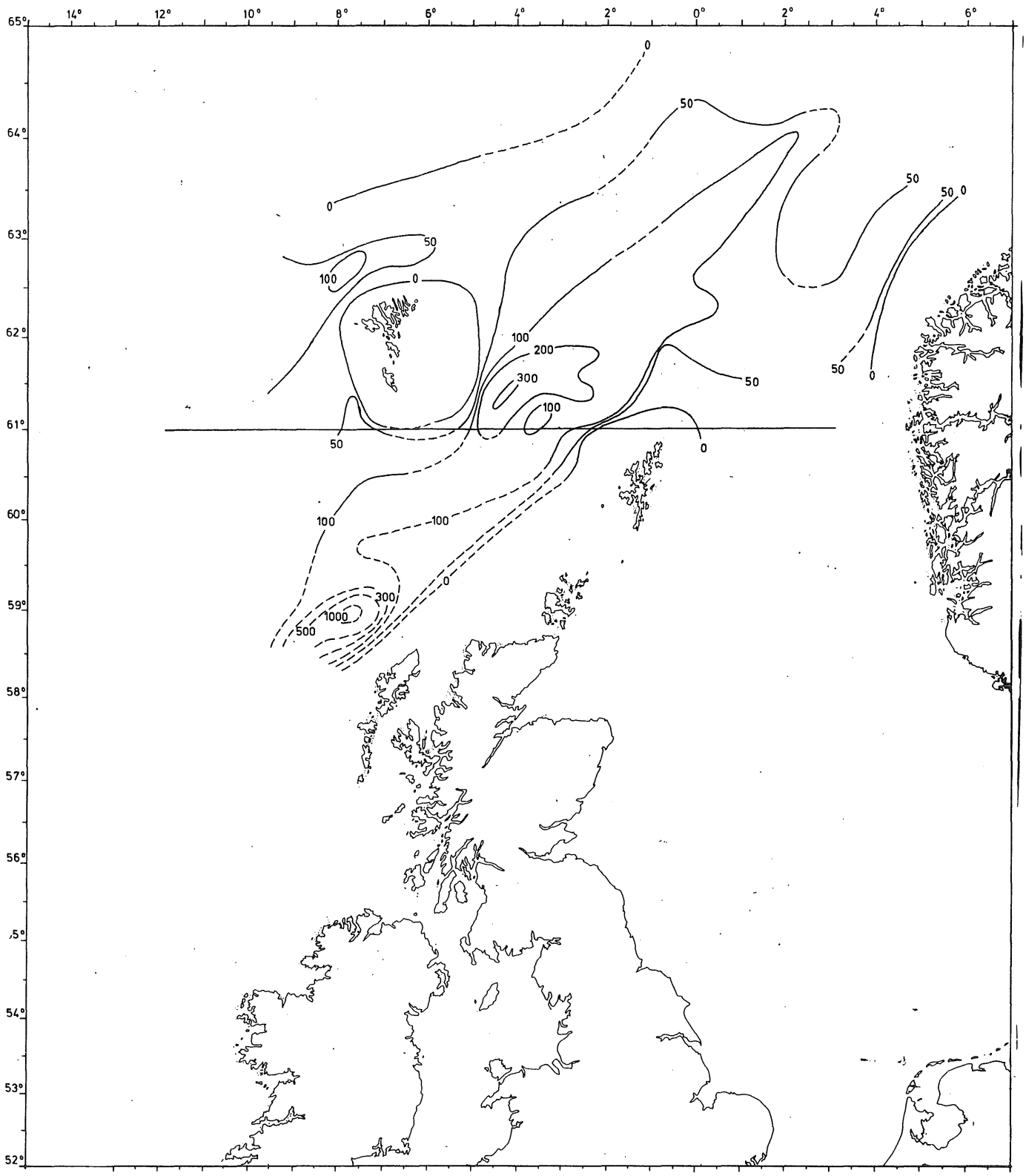

Fig. 3. Integrated echo intensity (mm/n.mile) of blue whiting, "G.O. Sars" 9-20 March 1981.

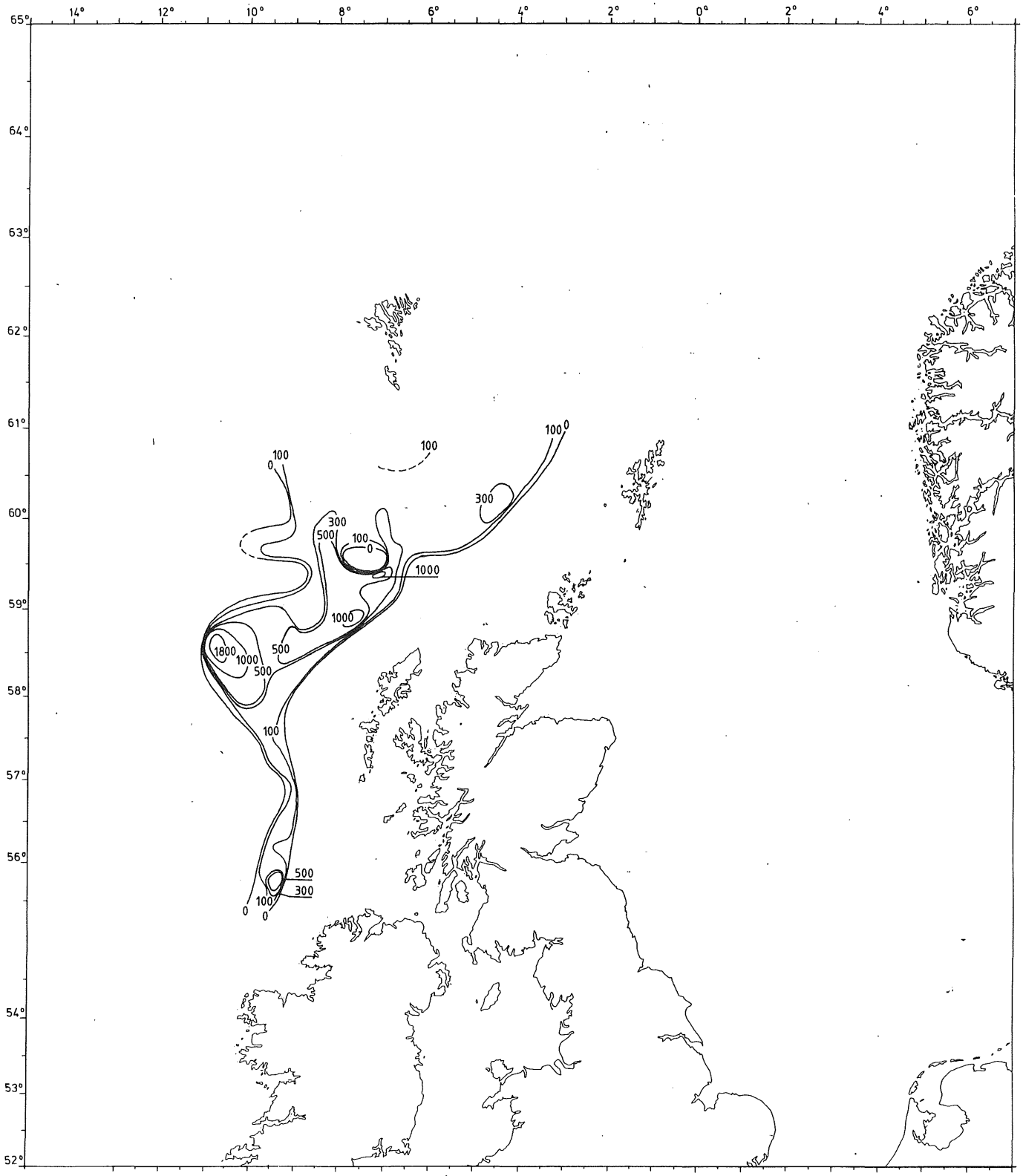

Fig. 4. Integrated echo intensity (mm/n.mile) of blue whiting, "G.O. Sars" 20 March-1 April 1981.

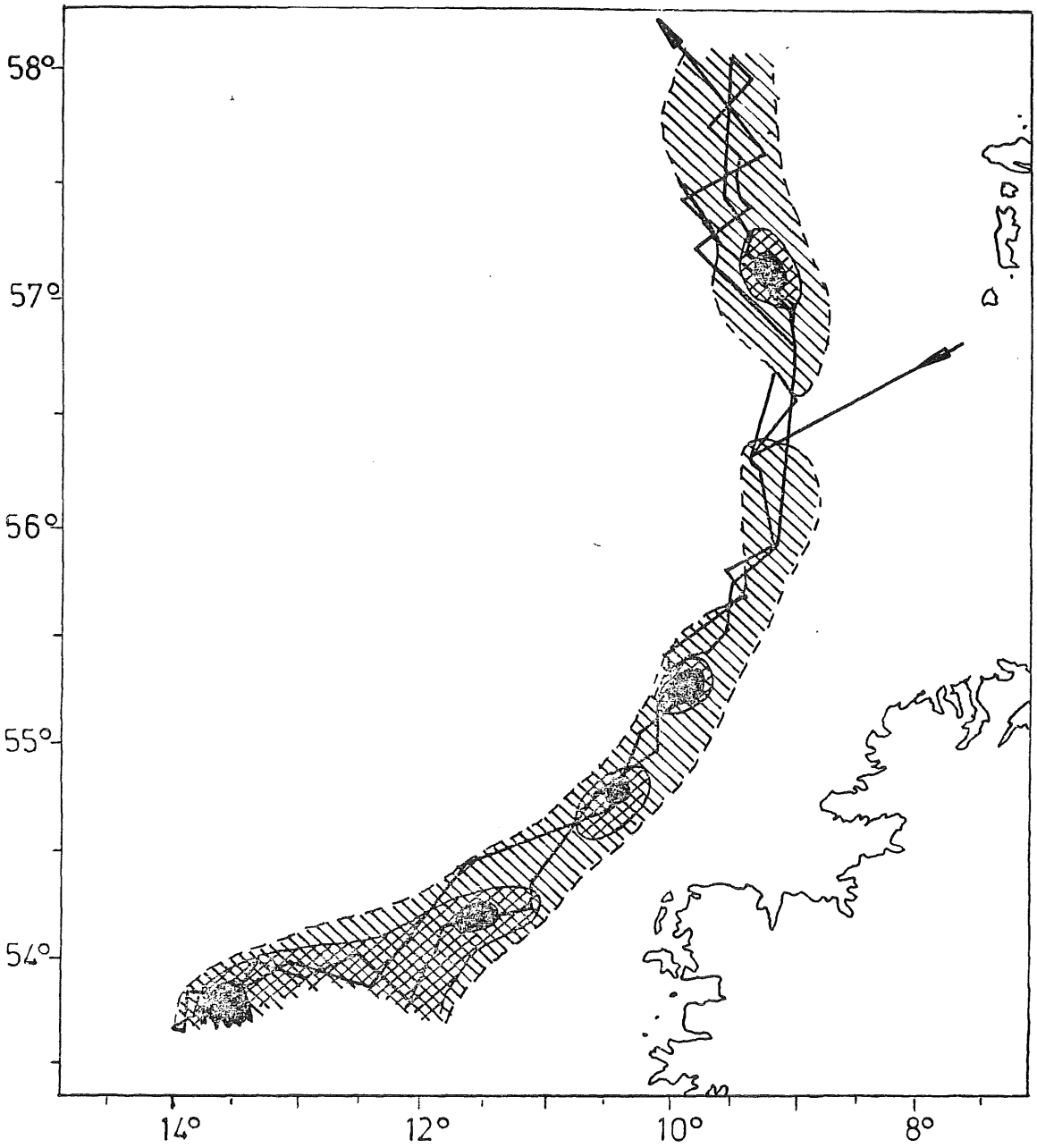

Fig. 5. Cruise track of "Michael Sars" with recordings of blue whiting 20-28 March 1981. Black areas indicates highest concentrations.

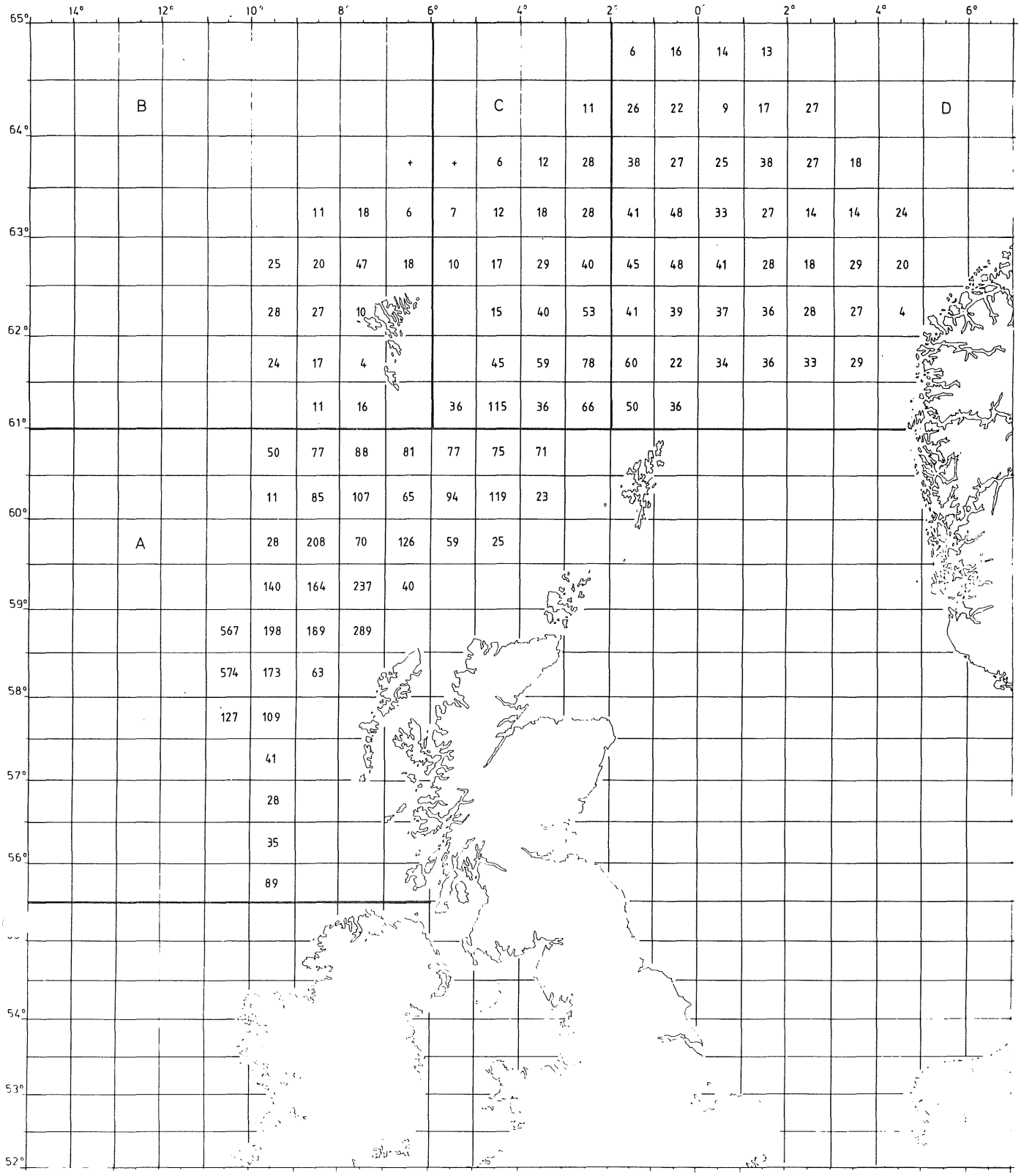

Fig. 6. Distribution and densities in thousand tonnes of blue whiting 9 March-1 April 1981.

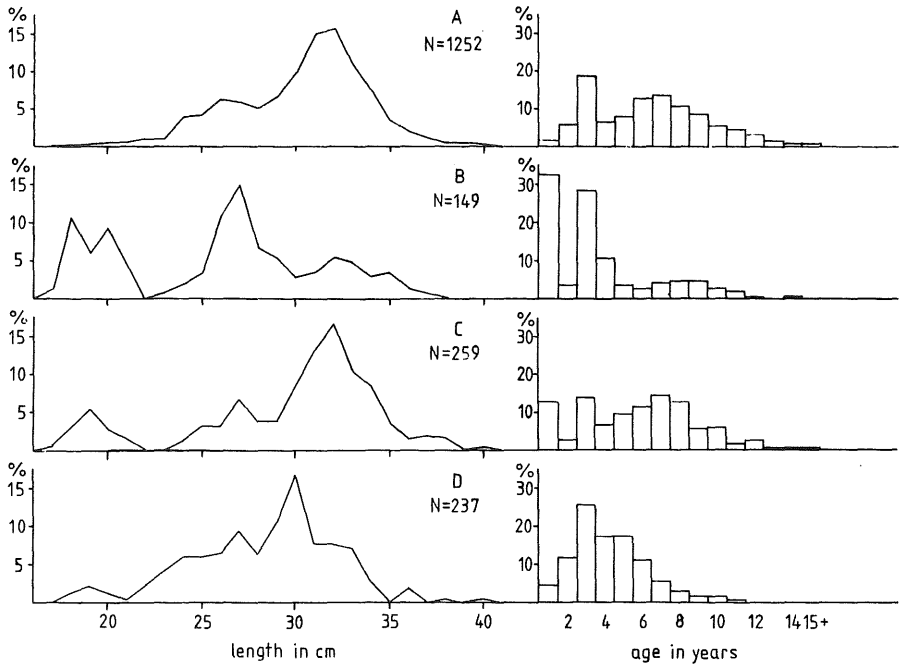

Fig. 7. Length- and age-compositions in percentage of blue whiting in four areas which is outlined in Fig. 6.
A) N and W of the Hebrides, B) W of the Faroes, C) E of the Faroes, D) N and NE of Shetland.

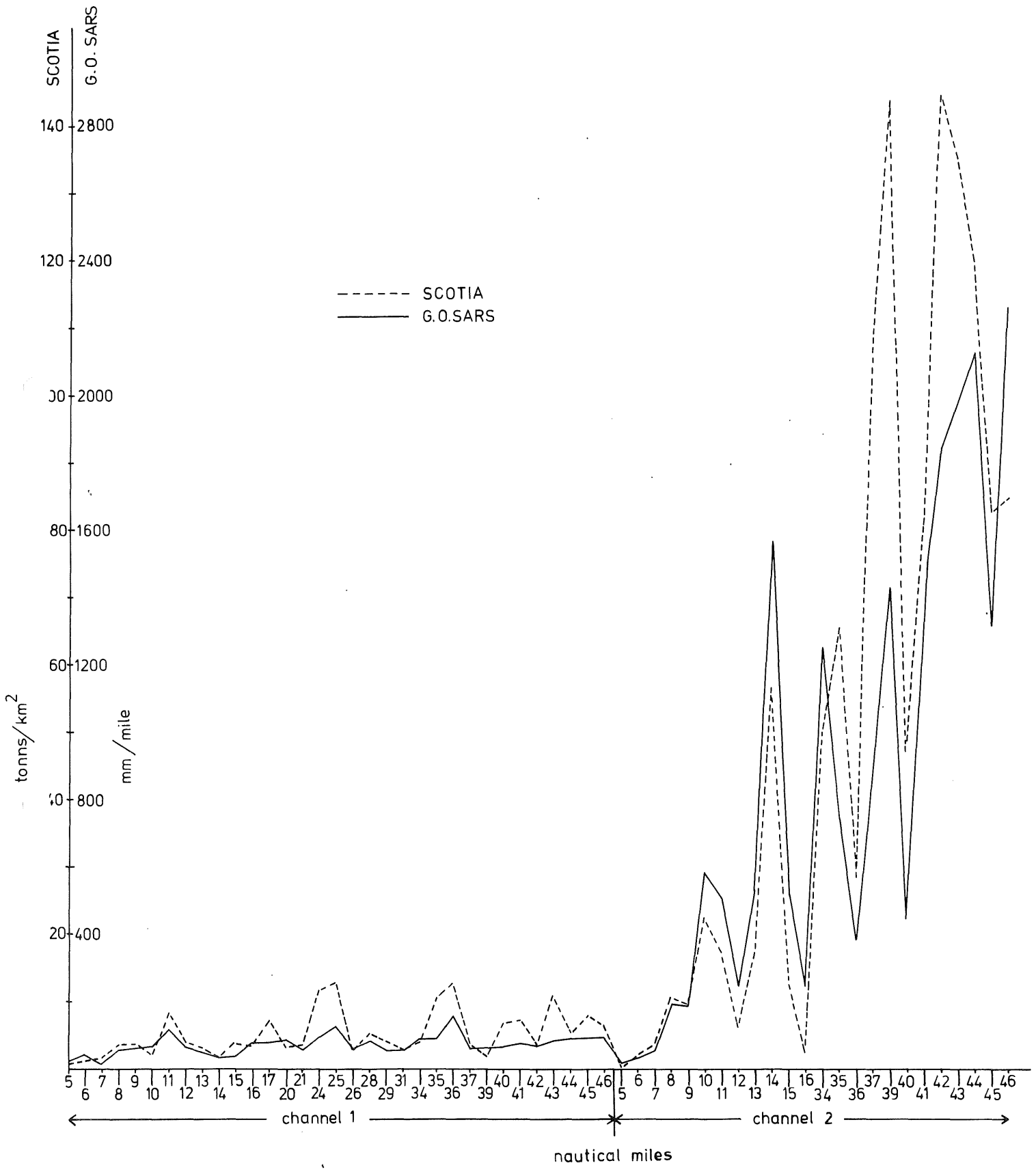

Fig. 8. Recorded densities per nautical mile of "Scotia" (biomass in tonnes/km^2) and "G.O.Sars" (integrator values in mm deflection/nautical mile) during inter-calibration 27 March 1981.

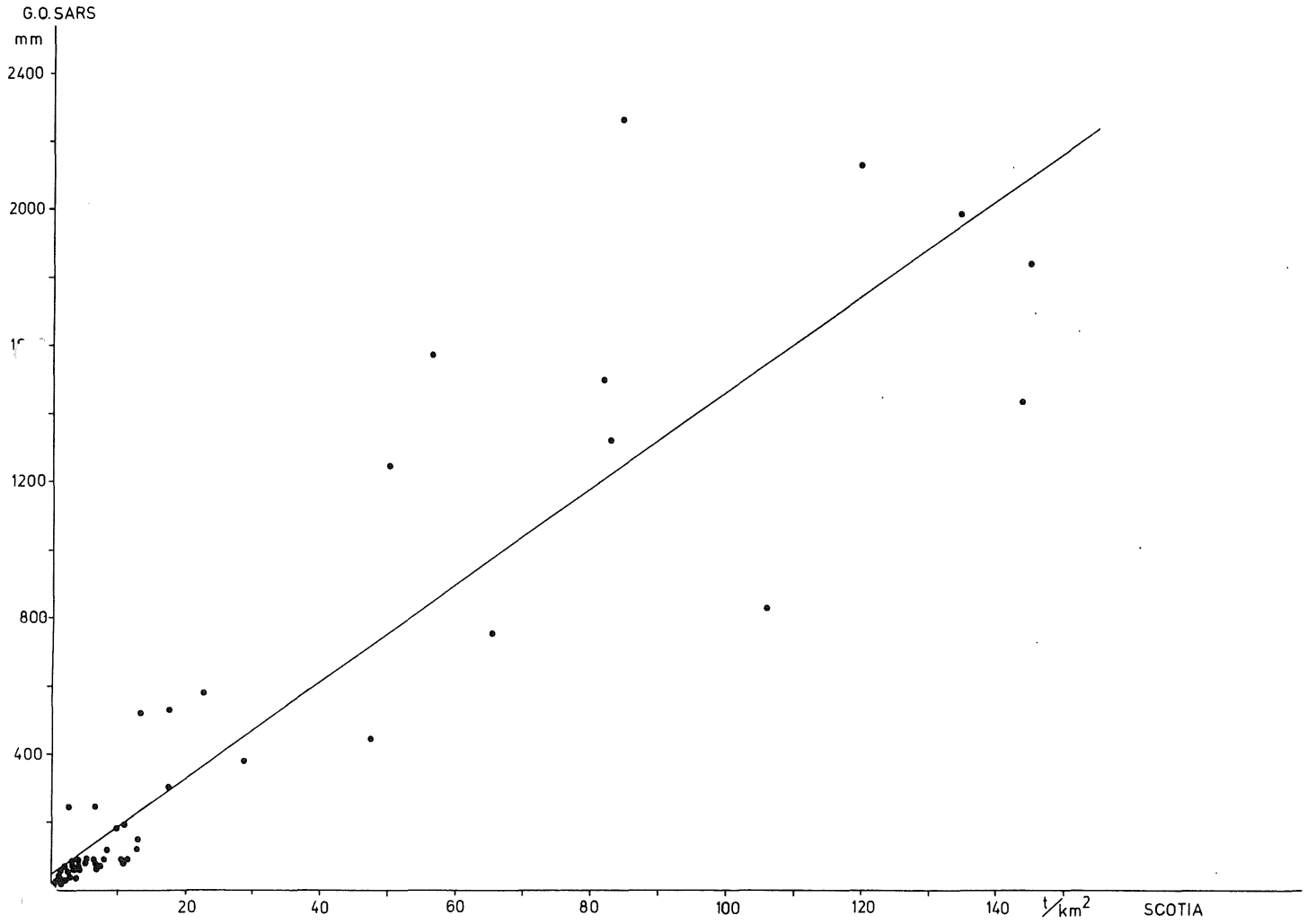

Fig. 9. Relationship with regression line of recorded densities of "Scotia" and "G.O. Sars" 27 March 1981.

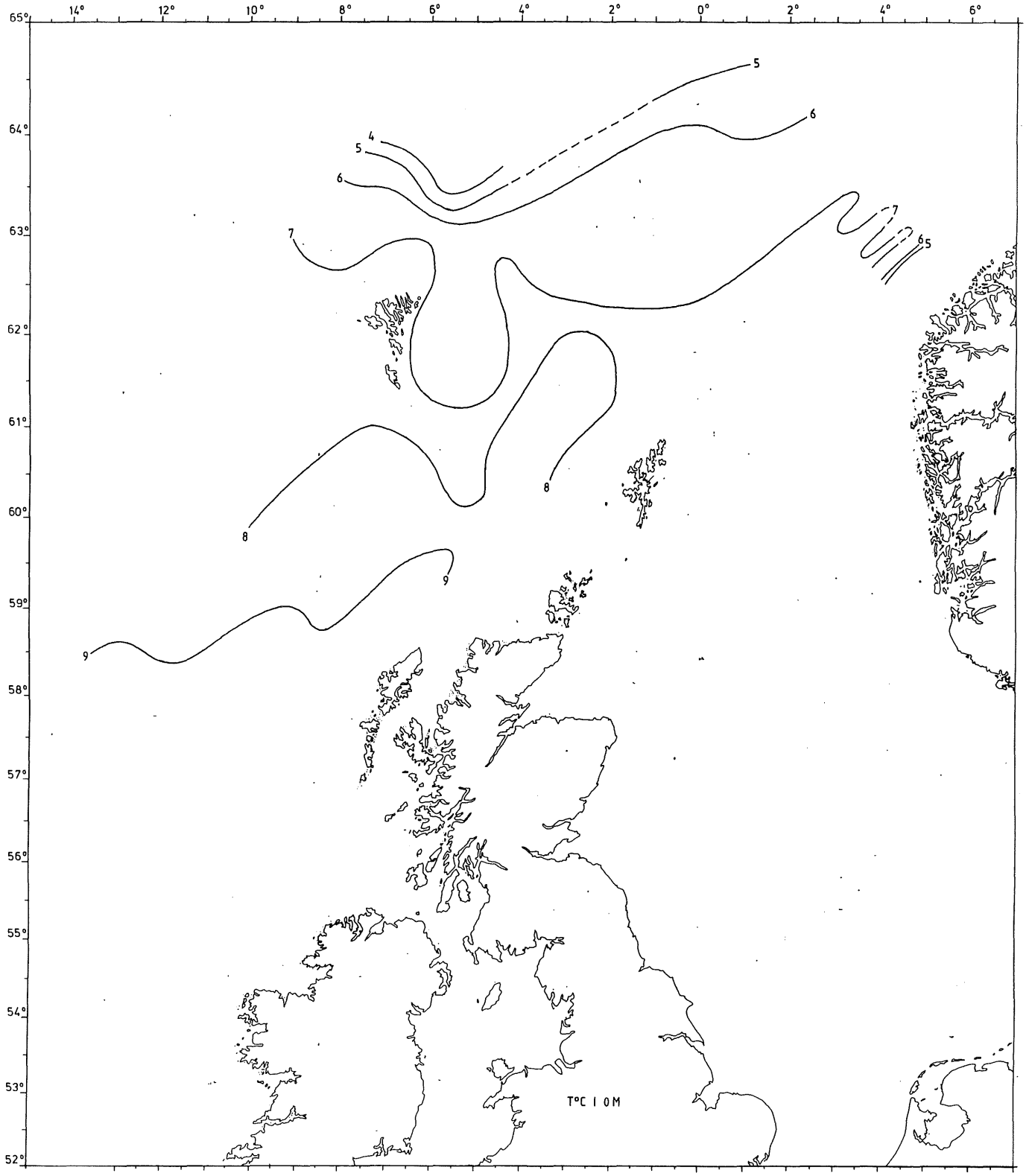

Fig. 10. Temperature of surface, March 1981.

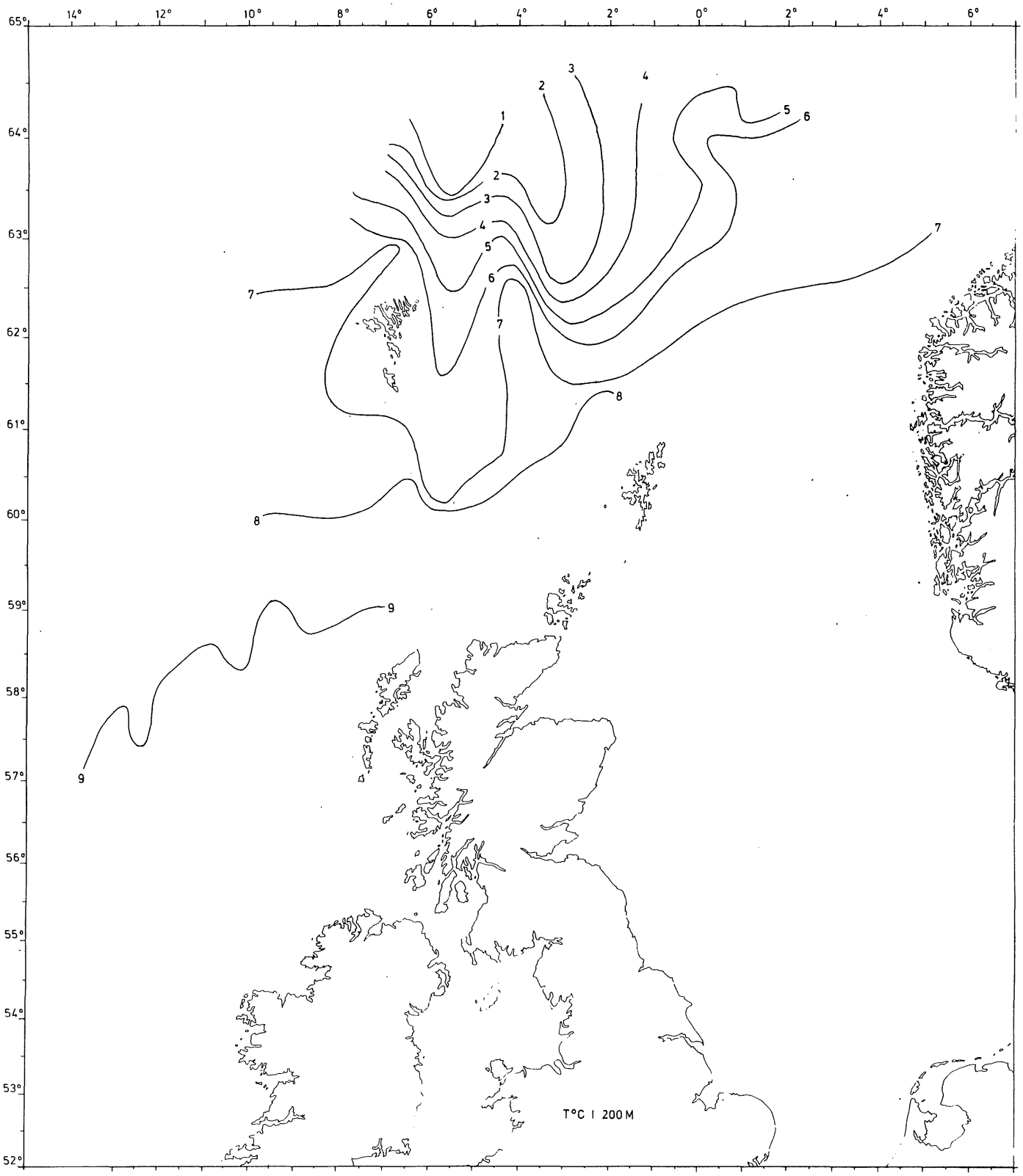

Fig. 11. Temperature at 200 m depth, March 1981.

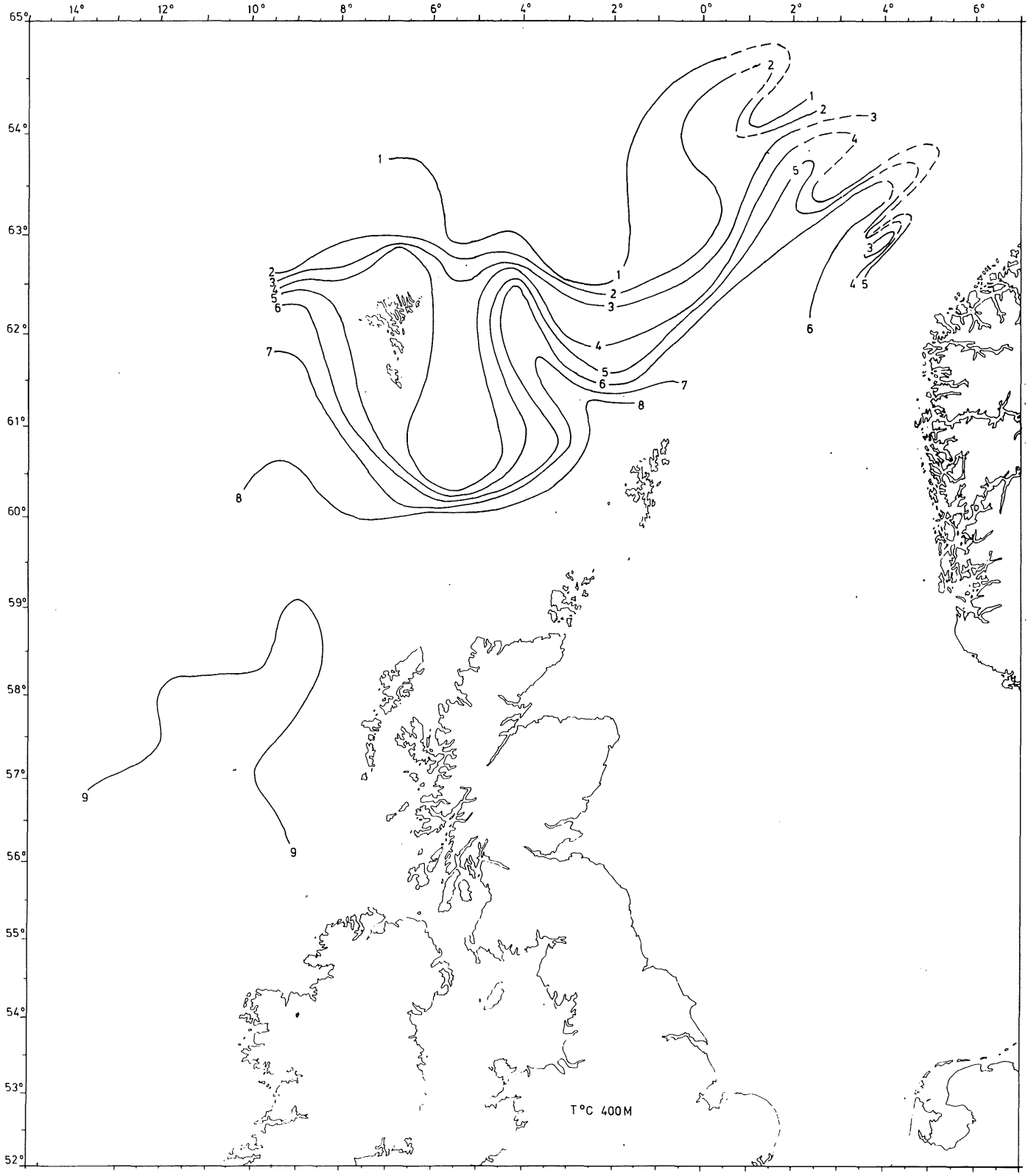

Fig. 12. Temperature at 400 m depth, March 1981.

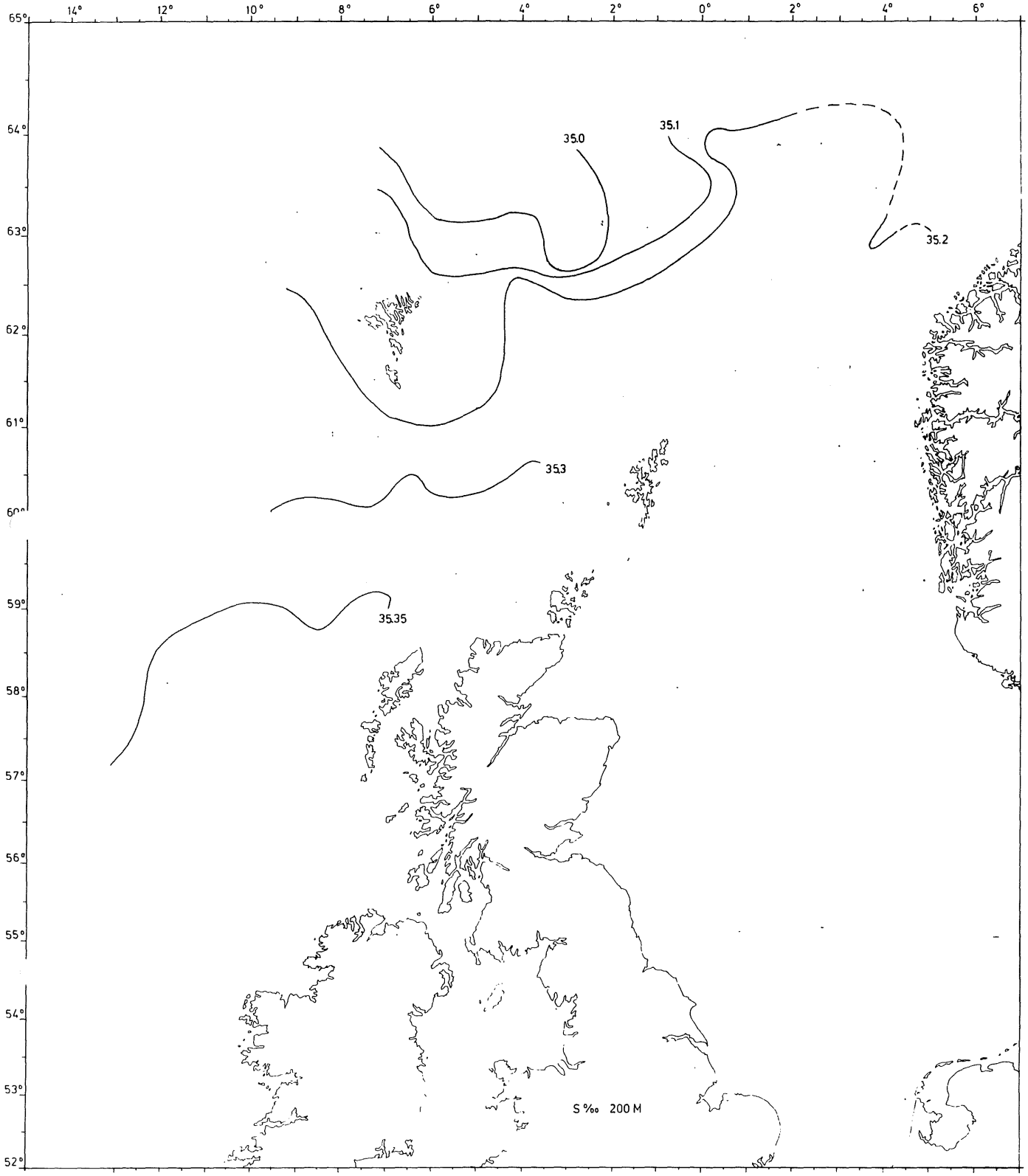

Fig. 14. Salinity at 200 m depth, March 1981.

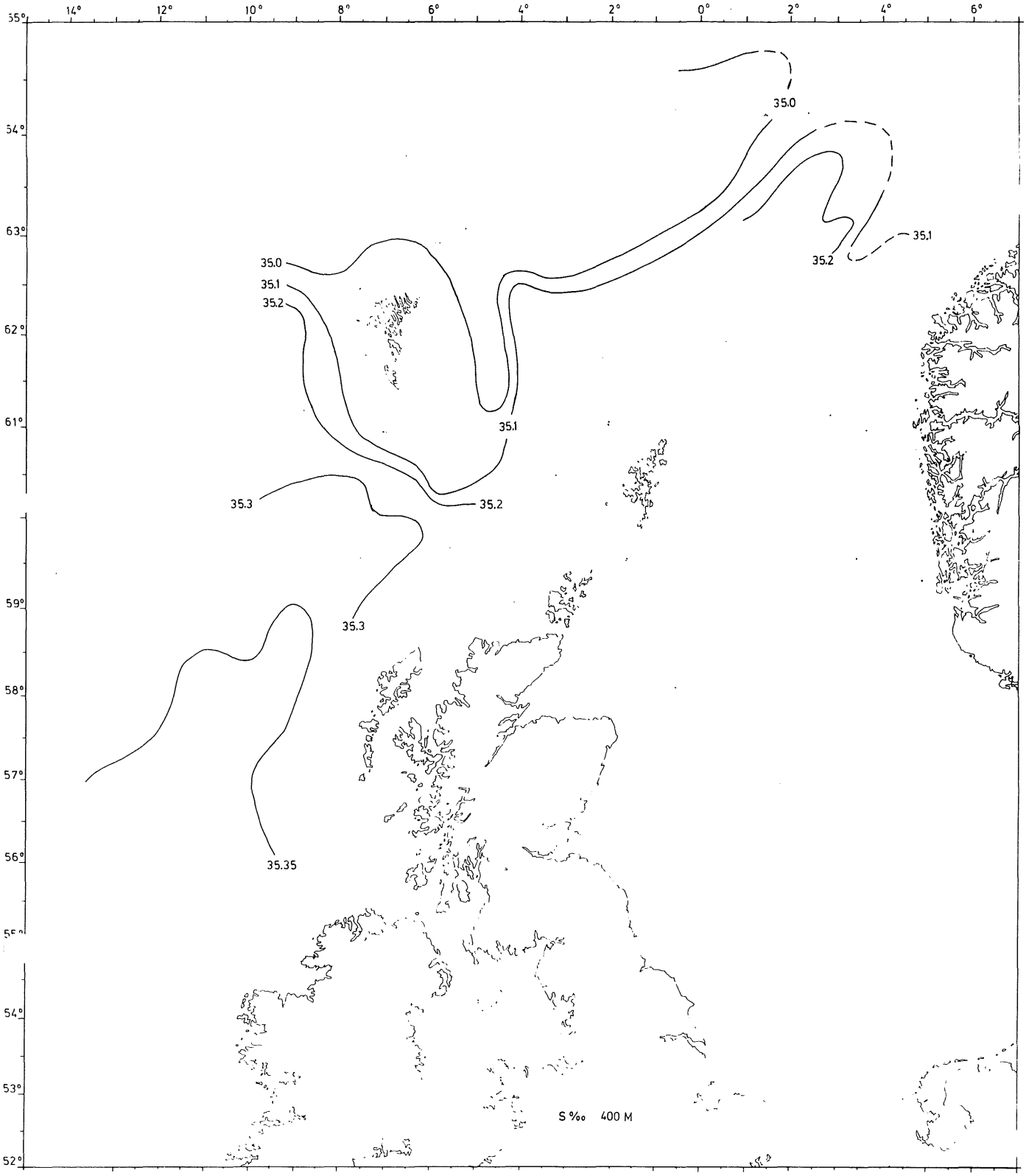

Fig. 15. Salinity at 400 m depth, March 1981.

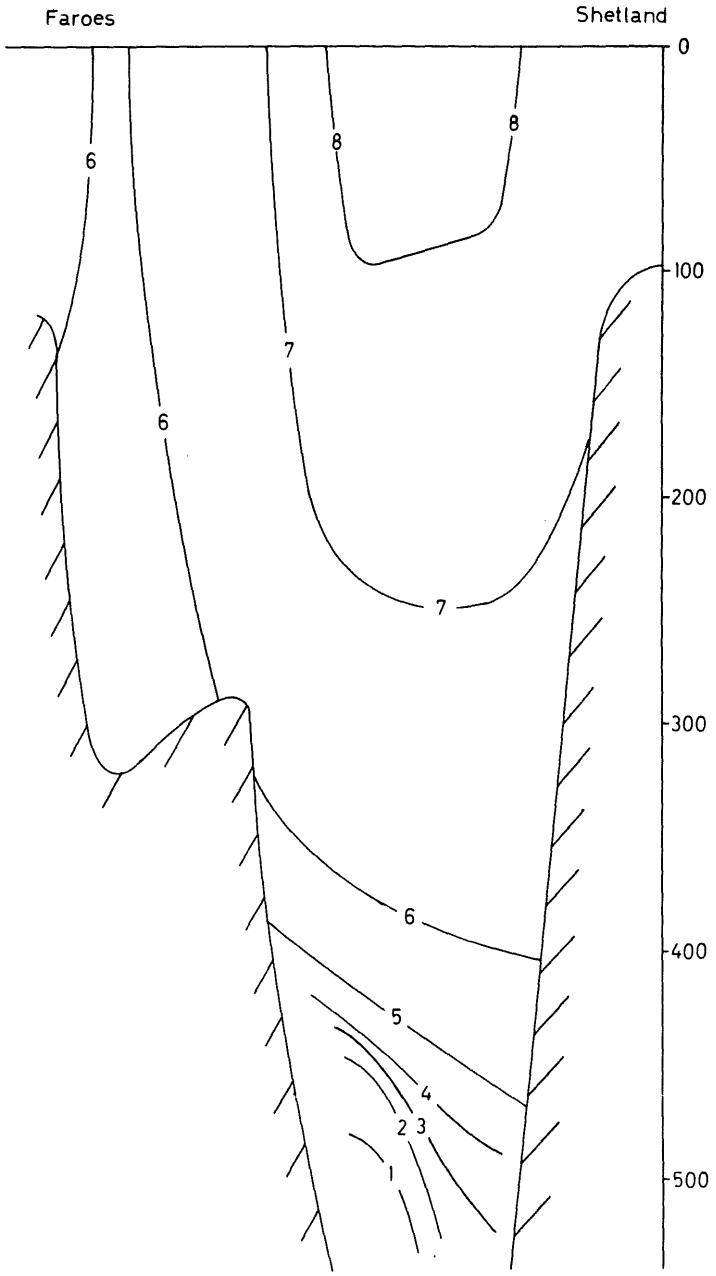

Fig. 16. Temperature ($t^{o}C$) in a vertical section between the Faroes and Shetland, March 1981.

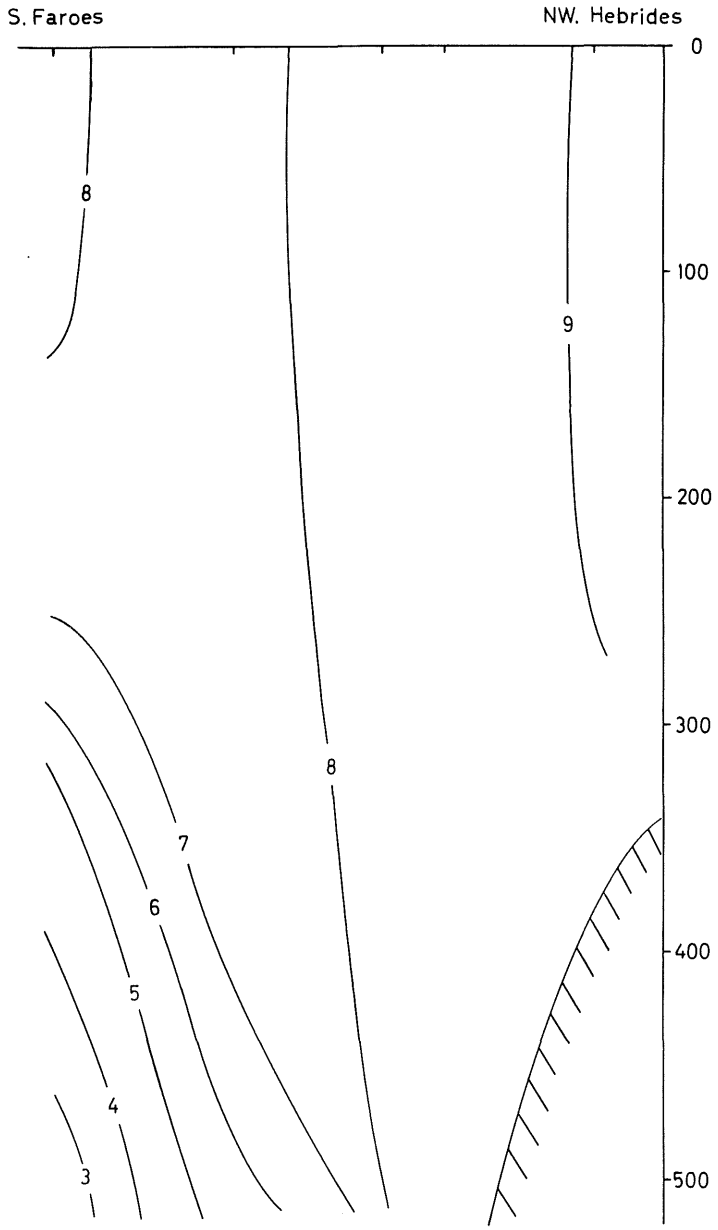

Fig. 17. Temperature ($t^{o}C$) in a vertical section between the Faroes and the Hebrides, March 1981.